TITLE PAGE

Title: Using misleading online media articles to teach critical assessment of scientific findings about weight loss

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Abbreviated title: Teaching critical thinking with media articles

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ABSTRACT

In this paper, a teaching strategy that exploits misleading media articles covering peer-reviewed research is described. This task attempts to encourage university students to not take media articles on obesity physiology at face value. Briefly, the task is divided into three main sections: 1) information on the study and media headlines is provided, and students complete a blank template with hypothetical data reflective of the headlines; 2) a consensus is met on hypothetical data that would accurately reflect the media headlines; and 3) true data are revealed and discussion takes place as to how accurate the media headlines are with respect to the published data. This task has been piloted in two cohorts (*n* = 149 students), and feedback has been collated from 79 of these students. Overall, it appears that this task was well received [student rating (mean ± SD): 4 ± 1 arbitrary units on a scale of 1 to 5, where 1 = poor and 5 = excellent]. Feedback highlighted key aspects to consider when delivering this session are the suitability of the room, and a re-emphasis of the aims and outcomes of the session at the end. In summary, this paper describes a teaching strategy that makes use of media articles reporting on published studies in an attempt to promote critical thinking in undergraduate students. Whilst the example provided covers the physiology of obesity, this can be readily applied to other physiological topics.

Keywords: critical thinking; weight loss; exercise; teaching methods

INTRODUCTION

The ability to think critically is one of the most important skills that higher education can offer (22). Critical thinking is highly transferable, relevant to everyday life, and is useful in rational decision making (24). Critical thinking has been defined as the ability to assess, interpret and evaluate ideas, concepts or arguments, and to examine the reasons for believing something (4). At a time when it appears that many people can be convinced by public statements that are taken at face value (8), and with increasing use of the Internet and social media with unreliable sources of information, the ability to think critically whilst being open minded appears to be as important as ever. Previous work has described indirect methods of teaching to develop critical thinking using physiological principles (4). The aim of this article is to highlight another strategy to promote critical thinking whilst also highlighting the transferable nature of this skill in interpreting information gathered in everyday life. The focus is on obesity but can be applied to many other areas of physiology that are highlighted in the media.

Physiology of Obesity

The physiological causes of weight gain and weight loss are often misunderstood (5). Therefore, this topic may be a particularly effective context in which to entrain critical thinking. Due to this common misunderstanding, an overview of the main factors that dictate energy balance, body mass, and fat mass will be briefly discussed.

Whilst many physiological and non-physiological (e.g. sociological) factors influence our propensity to be more or less physically active or to eat more or less food, obesity is primarily the result of a sustained positive energy balance (2, 11). Metabolizable energy intake is the energy that is orally ingested from foods and drinks (as carbohydrate, fat, protein, fibre and ethanol), minus the amount of energy that is not absorbed, but is excreted in faeces (11, 14, 25). Since energy excretion in faeces is a relatively small quantity and relatively stable across time, then the primary factor dictating metabolizable energy intake is the quantity of energy ingested. A caveat to this is the assumption that nutrients are absorbed across the intestine as the same nutrient that was ingested, which may not be the case with fermentable carbohydrates that can be converted to short chain fatty acids by the gut microbiome (13). The importance of the gut microbiome in harvesting energy from ingested food and thus its role energy balance in increasingly appreciated (26).

The primary components of energy expenditure are resting metabolic rate (RMR), diet induced thermogenesis (DIT) and physical activity energy expenditure (PAEE). Inter-individual differences in RMR are primarily driven by differences in lean body mass (19), whereas differences in DIT are mainly due to differences in energy intake and diet composition (27). Whilst there are some other minor components of energy expenditure, such as cold-induced thermogenesis, these are not major contributors to energy balance [e.g. cooling ambient temperature from 24 ºC to 19 ºC increases energy expenditure by only ~88 kcal·day^{-1} (6)]. For perspective, the variability in physical activity energy expenditure (which encompasses both exercise and non-exercise activity thermogenesis; i.e. NEAT(16)) in a non-athletic population can vary by more than 1300 kcal·day^{-1} (30).

If one considers the starting point of a neutral energy balance (**Figure 1A**), the initiation of a positive energy balance can be as a result from either: 1) a decrease in energy expenditure (**Figure 1B**); 2) an increase in energy intake (**Figure 1C**); and 3) a combination of both reduced energy intake and increased energy expenditure. Notably, a change in one component of energy balance can have important implications for other energy balance components. This can erode an initial expected energy surplus or energy deficit (2, 7, 31). These compensatory behaviors are largely the result of powerful physiological feedback mechanisms as illustrated by the increase in appetite and energy intake in response to covert manipulation of energy expenditure (12). The net effect of these compensatory behaviors on energy balance is therefore the primary factor dictating changes in body mass over time, and therefore obesity risk.

Whilst the evidence is clear that energy balance is the main determinant of changes in body mass over time, this point still does not appear to be appreciated by the general public and mass media. Headlines such as “The secret to losing weight? Eat more!” (9) and “Eating MORE fat while cutting carbs and quitting sugar can help you lose weight and be happier, says top cardiologist” (21) appear to suggest that diet composition, independent from energy balance, determines weight loss or weight gain. Furthermore, some headlines suggest that people with a high-genetic risk of obesity face a futile struggle to lose weight with diet (and/or) physical activity (20). However, genome-wide association studies suggest that common genetic variation can only explain a minor fraction (<25%) of the variation in body mass index (18). Furthermore, there is clear evidence that the relationship between genetic variation and body mass index is at least halved in a physically active population (17). Therefore, there is clear evidence that genetics play a minor role in common obesity, and physical activity and diet are stronger factors determining body mass.

When considering the role of energy balance in obesity, it is important to still recognize that macronutrient composition of the diet can still have powerful effects on body weight and body composition, potentially via changes in appetite, protein synthesis rates, body water content and/or insulin secretion (10, 23, 29). Thus, whilst energy balance is the primary factor driving body weight, other factors do make a contribution. Interestingly, however, even the effect of reducing insulinemia appears to protect against weight gain primarily by increasing energy expenditure rather than by direct changes in fatty acid mobilization and utilization (23).

The confusing and conflicting messages provided by the media can however, be harnessed to teach the ability to think critically to undergraduate students. The aim of this article is to describe a teaching strategy for undergraduate students that utilised the conflicting messages provided by media articles. In doing so, it is hoped that students appreciate the value in questioning statements, such as those in the media, and assessing the underlying evidence to form their own view on a topic.

Overview of teaching sessions and target student population

Since the example provided requires some prior knowledge of the physiology of obesity and some appreciation of critical thinking, this teaching strategy is well-suited to undergraduate students towards the latter stages of their degree. The general principle of this strategy can be applied to many media articles that are published, but herein is described one specific example, which is comprised of three main phases

Phase One – Background information and completion of blank template

Students are provided with a published newspaper article with the title "Going to the gym could make you FAT: Genes blamed for weight gain may block the effects of exercise" (20) and the subheadings:

- "So-called obesity genes could make exercise less beneficial, study found"
- "Women with high levels of the genes gained weight despite working out at the gym three times a week for a year"
- "Those with low levels of the same genes lost weight over the year"
- "Muscle-gain didn't play a part and experts say results could be because the 'obesity' gene make people feel hungrier in the wake of a workout"(20)

This newspaper article is based on a study published in a respectable peer-reviewed journal (15). Students are provided with some of the key details of the study, which were that this was a block randomized trial examining the effect of resistance training on bone and body composition in early post-menopausal women. One-hundred and forty-eight post-menopausal women were randomized to either an exercise group (intervention; *n* = 84) or a no exercise group (control; *n* = 64) stratified for use of hormone replacement therapy. Those randomized to the exercise group performed supervised 75-min sessions of resistance training, 3 days per week for 12 months. Before and after the intervention, body mass and composition were determined by dual-energy x-ray absorptiometry (DEXA) (15). Participants were subsequently grouped according to "low", "moderate" or "high" genetic risk of obesity based on 21 single nucleotide polymorphisms (SNPs) that have previously been associated with body mass index.

Students are then provided with a task (in groups of 3-5 students), which is to complete a paper-based template comprised of a three-panel figure (**Figure 2**). This figure presents panels that are blank, to allow data to be drawn, but with the x- and y-axes already labelled. The y-axis of **Figure 2A** represents the change in body mass; **Figure 2B**, the change in fat mass; and **Figure 2C,** the change in lean mass. The x-axis of all figures is identical, from left to right labelled, “Low Genetic Risk”, “Intermediate Genetic Risk”, and “High Genetic Risk”. Ideally, the data from this type of study design should be assessed on the between-group post-scores using an ANCOVA, with baseline values as the covariate (3). However, for simplicity, the students are asked to provide the data as change scores (positive for an increase and negative for a decrease) with error bars representing 95% confidence intervals (to indicate whether there is a change from baseline) and demarcation of between-group effects with an asterisk. An approximate time-frame of 15 minutes is provided to complete the activity, which is dependent on the number of students present. During the activity, the tutor (in this case the Professor) visits each group to engage with the students, check on progress, and to answer any outstanding questions from the students that are required to complete the activity.

Phase two – Consensus on hypothetical data reflective of headlines

Once all groups have completed the activity, the class is brought together to come to a consensus. The tutor asks various groups to contribute their answers and draws on the completed template on a board (or this can be performed on a computer with projection). **Figure 3** represents an example of what the data could look like if they represented the headlines of the newspaper. For the quote: “Women with high levels of the genes gained weight despite working out at the gym three times a week for a year", the data show that the group with the "High genetic risk" display an increase in body mass from baseline (indicated by the 95%CI not overlapping 0), and this group display an increase in body mass compared to the "Low genetic risk" group (**Figure 3A**). These hypothetical data would be consistent with the statement that the population with the high genetic risk scored gained weight in spite of the exercise training intervention.

For the quote "Going to the gym could make you FAT: Genes blamed for weight gain may block the effects of exercise" a similar pattern of hypothetical data is shown, but this time for the change in fat mass. The groups with "low" or "moderate" genetic risk display a reduction in fat mass in response to the training intervention, whereas the group with high genetic risk score display an increase in fat mass in response to the training intervention, with a statistically significant difference in fat mass response between the "high" versus the "low" genetic risk groups (**Figure 3B**).

Figure 3C displays the hypothetical data that would support the quote "Muscle-gain didn't play a part", assuming of course, that the journalist is referring to the change in body mass when referring to "a part". There could be multiple options to display hypothetical data supporting that statement. The chosen option displayed to students shows that none of the groups gained or lost lean body mass during the intervention, and therefore changes in body mass must be due to factors other than lean mass.

<u>Phase three – Revelation and discussion of true data</u>

The final phase of the teaching exercise is to reveal the data presented in the published paper (15). The figures were redrawn from the original paper and the 95%

confidence intervals were calculated from the standard error as previously described (1). Students are presented with **Figure 4** and are asked to state a conclusion based on the data. As can be seen from **Figure 4A**, none of the groups lost or gained body mass following the intervention (as indicated by the 95%CI overlapping 0 for all groups). Furthermore, there was no difference between groups in the change in body mass.

Figure 4B illustrates that the "low genetic risk" group demonstrated a reduction in fat mass in response to the intervention, however, the "intermediate" and "high" risk groups did not show a reduction in fat mass. This provides a further discussion point for the students, as the change from baseline in the "low risk group" that was not seen in the other two groups, is often interpreted as consistent with the statement "Genes blamed for weight gain may block the effects of exercise". However, without a statistical comparison *between* groups, this interpretation may be premature (3).

Figure 4C demonstrates the true data for lean mass. Both the "low" and "high" generic risk groups displayed an increase in lean mass in response to training. These data are therefore in direct conflict with the statement "Genes blamed for weight gain may block the effects of exercise". Moreover, they are also in direct contrast with the statement "Muscle-gain didn't play a part". Since lean body mass has changed during the intervention, changes in body mass must be due (in part) to changes in lean mass.

After the revelation and initial discussion of the data, the teaching exercise can be expanded further. Students are asked whether they agree with the conclusions drawn by the authors of the paper. Students can also discuss the reasons for why data can be misrepresented by authors' conclusions, and further still by mass media report. Areas to discuss here can include the pressure to publish and publication bias, the pressure to achieve impact outside of academia, and the misinterpretation by university press offices and journalists.

Student perceptions and feedback

This teaching strategy has been trialled over two years on an undergraduate Sport and Exercise Science course. Since the data reported were collected as part of normal education practices at the institution, a full review by the institutional review board was not required for this study due to exemption 45 CFR 46.101(b)(1), as per US Department of Health and Human Services guidelines (28). In year one this session was delivered to 65 students. In year two, this session was delivered to 84 students. Students have anonymously provided quantitative and qualitative feedback that is, on the whole positive. The responses to the question posed "Please rate the quality of teaching [by this tutor] from [Poor (1) to Excellent (5)]" resulted in a mean rating of 4 ± 1 arbitrary units (mean ± SD) across both years, with a response rate of 52% and 54% in year 1 and year 2, respectively. Whilst this question is not specific to the activity, the tutor only delivered one session on this unit, and because the major focus of this session was the task described, it is assumed that these scores are largely reflective of the perceptions of this activity (including the delivery of the activity by the tutor).

Some of the positive comments from students included: "Really enjoyed the interactive sessions", "Enjoyed the interactive tasks", and "Good approach to critical thinking". The room which this task was delivered in was a tiered lecture theatre as part of a long-term booking. Some students highlighted that the teaching space could have been better suited to the task: “A better teaching room so that the interactive tasks are easier to do!” and “Group discussion doesn’t work very well in a lecture setting”. Therefore, it is recommended that this is performed in a flat room with a seating arrangement that is suited to group work. Others were less positive about the task: “I found the interactive elements of the unit hard to learn from, as the class is giving so many different ideas and opinions on the questions, it is hard to know what is the ‘right’ answer, or way of answering”. It is therefore clear that the task was, on the whole, well received, but some students may require more clarity at the end summary of the aims of the task and the take away messages.

Summary and conclusion

To summarise, media articles were used in a task when teaching obesity physiology with a three-step approach:

1) *Background information and completion of blank template* – Information on the study design and media headlines is provided, and students complete a blank template with hypothetical data that are reflective of the headlines

2) *Consensus on hypothetical data reflective of headlines* – Students share their answers with the wider group. A consensus is met on hypothetical data that would accurately reflect the media headlines

3) *Revelation and discussion of true data* – The true data are revealed, and discussion takes place as to how accurate the media headlines and the authors’ conclusions are with respect to the published data.

In conclusion, the task described appears to have worked well for undergraduate students in groups up to ~80 students. Key aspects to consider when delivering this activity are that the room should be suitable for promoting group discussion, and the summary at the end of the task should re-emphasise the purpose and outcomes of the session.

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AUTHOR CONTRIBUTIONS

J.T.G. conceived and designed the research; prepared figures; drafted manuscript; edited and revised manuscript; approved the final version of the manuscript

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FIGURE LEGENDS

Figure 1. Primary components of energy balance during hypothetical scenarios of neutral energy balance (**A**), and a positive energy balance of 1000 kcal per day achieved by either a decrease in energy expenditure (**B**) or an increase in energy intake (**C**). CHO, carbohydrate; FAT, fat; PRO, protein; RMR, resting metabolic rate; DIT, diet-induced thermogenesis; PAEE, physical activity energy expenditure (n.b. PAEE also captures non-exercise activity thermogenesis).

Figure 2. Blank template provided to students. Students are required to complete the figure with hypothetical data for body mass (**A**), fat mass (**B**) and lean mass (**C**) that reflect the quotes provided. Quotes are from reference 20.

Figure 3. Example of a completed template with hypothetical data that reflect the quotes in relation to body mass (**A**), fat mass (**B**) and lean mass (**C**). Quotes are from reference 20. Data are means ± 95%CI.

Figure 4. True data in relation to body mass (**A**), fat mass (**B**) and lean mass (**C**) redrawn from reference 15. Quotes are from reference 20. Data are means ± 95%CI.